AD-A097 986 COASTAL ENGINEERING RESEARCH CENTER FORT BELVOIR VA F/G 13/2

ESTIMATION OF FLOW THROUGH OFFSHORE BREAKWATER GAPS GENERATED B--ETC(U)

DEC 80 W N SEELIG, T L WALTON

UNCLASSIFIED CERC-CETA-80-8 NL

1 OF 1

END

DATE FILMED

5-81

DTIC

II (12)

CETA 80-8

Estimation of Flow Through Offshore Breakwater Gaps Generated by Wave Overtopping

by

William N. Seelig and Todd L. Walton, Jr.

COASTAL ENGINEERING TECHNICAL AID NO. 80-8
DECEMBER 1980

Approved for public release;
distribution unlimited.

U.S. ARMY, CORPS OF ENGINEERS
COASTAL ENGINEERING RESEARCH CENTER
Kingman Building
Fort Belvoir, Va. 22060

Limited free distribution within the United States of single copies of this publication has been made by this Center. Additional copies are available from:

National Technical Information Service
ATTN: Operations Division
5285 Port Royal Road
Springfield, Virginia 22161

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

14 CERC-

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER CETA-80-8	2. GOVT ACCESSION NO. AD-A097986	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) ESTIMATION OF FLOW THROUGH OFFSHORE BREAKWATER GAPS GENERATED BY WAVE OVERTOPPING		5. TYPE OF REPORT & PERIOD COVERED Coastal Engineering Technical Aid rept.
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) William N. Seelig; Todd L. Walton, Jr		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Department of the Army; Coastal Engineering Research Center (CERRE-CS); Kingman Building, Fort Belvoir, Virginia 22060		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS F31538
11. CONTROLLING OFFICE NAME AND ADDRESS Department of the Army; Coastal Engineering Research Center; Kingman Building, Fort Belvoir, Virginia 22060		12. ~~REPORT DATE~~ Dec ~~ember 1980~~
		13. NUMBER OF PAGES 21
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) 12 22		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Breakwaters	Wave height	Wave period
Offshore breakwaters	Wave overtopping	Waves

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents a method for estimating the net flow through the gaps of offshore segmented breakwaters caused by wave overtopping of the breakwaters. The method was developed so that either monochromatic or irregular waves can be specified. Example problems illustrate the effects of wave height and period, breakwater freeboard, spacing between breakwaters, and shore attachment on the flow rate. Computations may be done manually or by using the computer program, BWFLOW2, available from the Corps of Engineers Computer Library, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

DD FORM 1473, 1 JAN 73 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

037050

PREFACE

This report describes a method for estimating the flow rate through the gaps of offshore segmented breakwaters caused by wave overtopping. Factors that can be investigated using this method are the influence of breakwater freeboard, wave height and period, breakwater length and spacing, number of breakwaters, distance offshore, water depth at the breakwater, and shore attachment on the flow rate. Other wave effects on hydraulics, such as diffraction, refraction, reflection, and wave-current interactions, have not been considered. The work was carried out under the offshore breakwaters for shore stabilization and evaluation of shore protection structures programs of the U.S. Army Coastal Engineering Research Center (CERC).

The report was prepared by William N. Seelig and Dr. Todd L. Walton, Jr., Hydraulic Engineers, under the general supervision of Dr. R.M. Sorensen, Chief, Coastal Processes and Structures Branch and Dr. J.R. Weggel, Chief, Evaluation Branch.

Comments on this publication are invited.

Approved for publication in accordance with Public Law 166, 79th Congress, approved 31 July 1945, as supplemented by Public Law 172, 88th Congress, approved 7 November 1963.

Ted E Bishop
TED E. BISHOP
Colonel, Corps of Engineers
Commander and Director

A

CONTENTS

TABLES

FIGURES

CONVERSION FACTORS, U.S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U.S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	by	To obtain
inches	25.4	millimeters
	2.54	centimeters
square inches	6.452	square centimeters
cubic inches	16.39	cubic centimeters
feet	30.48	centimeters
	0.3048	meters
square feet	0.0929	square meters
cubic feet	0.0283	cubic meters
yards	0.9144	meters
square yards	0.836	square meters
cubic yards	0.7646	cubic meters
miles	1.6093	kilometers
square miles	259.0	hectares
knots	1.852	kilometers per hour
acres	0.4047	hectares
foot-pounds	1.3558	newton meters
millibars	1.0197×10^{-3}	kilograms per square centimeter
ounces	28.35	grams
pounds	453.6	grams
	0.4536	kilograms
ton, long	1.0160	metric tons
ton, short	0.9072	metric tons
degrees (angel)	0.01745	radians
Fahrenheit degrees	5/9	Celsius degrees or Kelvins[1]

[1]To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use formula: $C = (5/9)(F - 32)$.

To obtain Kelvin (K) readings, use formula: $K = (5/9)(F - 32) + 273.15$.

SYMBOLS AND DEFINITIONS

A_c cross-sectional flow area of gap between breakwaters

A_{ce} cross-sectional flow area between breakwaters and shoreline

a, b empirical runup coefficients

B breakwater gap width

C_d discharge coefficient for breakwater gaps

C_{de} discharge coefficient for space between breakwaters and shoreline

d_s water depth at the toe of the structure

F breakwater freeboard = $h - d_s$

g acceleration due to gravity

H wave height at the structure

H'_o equivalent deepwater wave height

H_s significant wave height at the structure

h structure height

h_b difference in mean water levels inside and outside of breakwaters

K a dimensionless parameter

L_o deepwater wavelength

ℓ breakwater length

ℓn log e

N number of breakwaters

P ponding level

$\bar{Q}$ mean net flow rate through a breakwater gap or inlet

Q_n net inflow by overtopping of a breakwater

Q^*_o empirical overtopping parameter

q_n net inflow by overtopping per unit length of a breakwater

q_o overtopping per unit length of breakwater with no return flow

R runup

SYMBOLS AND DEFINITIONS--Continued

T	wave period
$\bar{V}$	mean net water velocity for flow through a gap = $\bar{Q}/A_c$
v	dimensionless velocity
α	empirical overtopping parameter
θ	breakwater seaward-face slope angle
ξ	surf similarity parameter

ESTIMATION OF FLOW THROUGH OFFSHORE BREAKWATER
GAPS GENERATED BY WAVE OVERTOPPING

by
William N. Seelig and Todd L. Walton, Jr.

I. INTRODUCTION

Offshore breakwaters are often constructed to protect harbors or eroding coasts from wave action. Wave overtopping of segmented breakwaters generates a seaward flow through breakwater gaps. Low discharges and low water velocities are usually desirable in gaps between breakwaters. High velocities may be a hazard to navigation or swimmers, and large net exit flows through the gaps may transport sediment out of the breakwater area. This report illustrates a technique for predicting the net discharges and mean velocity through breakwater gaps caused by overtopping.

II. HYDRAULICS OF DETACHED BREAKWATERS

Since the cost of a breakwater increases with the height of the structure, it may be necessary to build the structure to allow some wave overtopping (Fig. 1). A moderate overtopping rate, which helps maintain water quality by encouraging circulation, may also be desirable. If the breakwater is impermeable the volumetric rate of overtopping per unit length by breakwater, q_o (assuming no return flow over the breakwater), may be predicted (Weggel, 1976; U.S. Army, Corps of Engineers, Coastal Engineering Research Center, 1977) by

$$q_o = \left(gQ_o^* H_o'^3\right)^{1/2} \left(\frac{R - F}{R + F}\right)^{\frac{0.1085}{\alpha}} \quad (1)$$

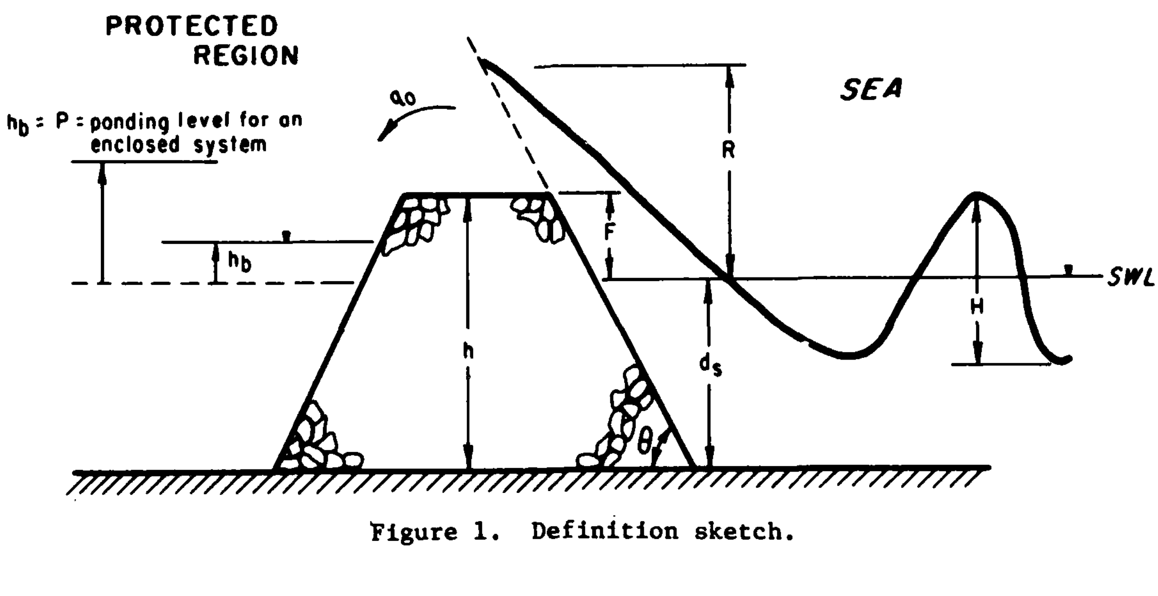

Figure 1. Definition sketch.

where

- g = the acceleration due to gravity
- H_o' = the equivalent unrefracted deepwater wave height
- R = the vertical height of runup on the structure if the breakwater were high enough so that no overtopping occurred
- F = breakwater freeboard = $h - d_s$
- h = the structure crest elevation
- d_s = the water depth at the toe of the structure.

Q_o^* and α are empirical overtopping coefficients found in the Shore Protection Manual (SPM) (U.S. Army, Corps of Engineers, Coastal Engineering Research Center, 1977, Ch. 7). Sample values of the empirical coefficients for an impermeable riprap structure with a 1 on 1.5 seaward slope are shown in Figure 2.

A first approximation of the wave runup on rubble-mound breakwaters may be estimated using the equation of Ahrens and McCartney (1975):

$$R = \frac{aH\xi}{(1 + b\xi)}; \quad \xi = \frac{\tan\theta}{\sqrt{\frac{H}{L_o}}} \tag{2}$$

where L_o is deepwater wavelength, and θ is the slope angle of the seaward face of the breakwater; the empirical coefficients $a = 0.692$ and $b = 0.504$ are recommended. Note.--Other methods for estimating runup on various structures may be found in the SPM (U.S. Army, Corps of Engineers, Coastal Engineering Research Center, 1977) and Stoa (1979).

Equations (1) and (2) were developed using monochromatic wave tests, so they should be used for swell wave conditions where the wave height and period from one wave to the next is approximately constant. The method of Ahrens (1977) for modifying equations (1) and (2) for irregular waves is recommended for irregular waves generated by nearby storms. The irregular wave overtopping prediction procedure is rather complicated, so the computer program BWFLOW2 (CERC program number 752X6R1ANC) is recommended for irregular waves. This program is available in the Corps of Engineers Computer Library at U.S. Army Waterways Experiment Station, Vicksburg, Mississippi. Note that the irregular wave overtopping method tends to be conservative because a Rayleigh wave height distribution is assumed, while the actual distribution may be truncated due to depth or steepness limited breaking.

1. Enclosed Breakwater Systems.

If the breakwater system is enclosed on either end by impermeable groins and the breakwater has no gaps, water overtopping the breakwater would cause the water level landward of the breakwater, h_b, to rise. Eventually, the zone landward of the breakwater would fill up to a ponding level where the seaward flow of water over the breakwater would equal inflow and the net flow, q_n, would be zero. Diskin, Vajda, and Amir (1970) tested a number of breakwaters

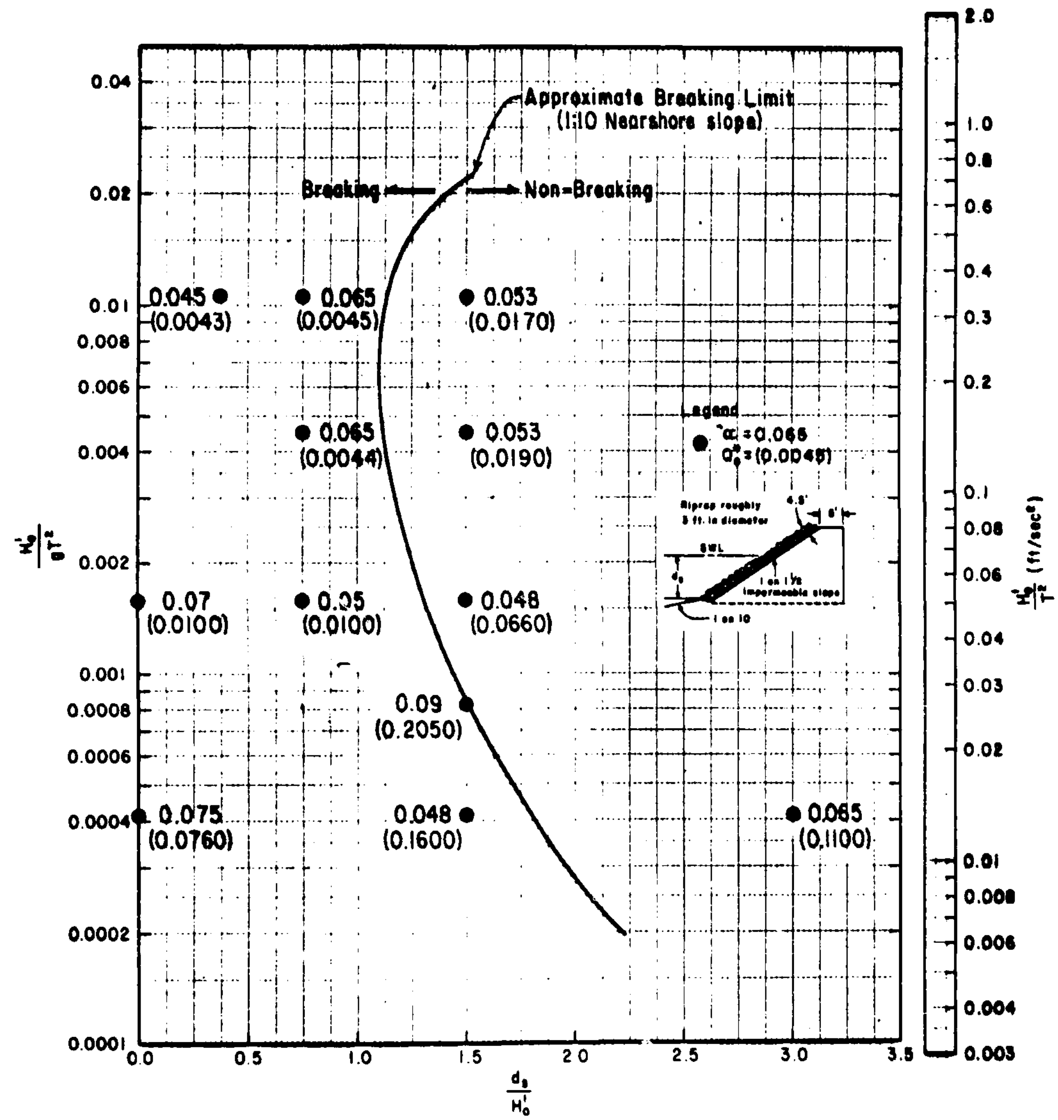

Figure 2. Overtopping parameters, α and Q_0^*, riprapped 1:1.5 structure slope on a 1:10 nearshore slope (from U.S. Army, Corps of Engineers, Coastal Engineering Research Center, 1977).

at various water depths, wave heights, and wave periods and found that the ponding level (Fig. 3) may be estimated from

$$\frac{P}{H_o'} = 0.6e^{-\left(-0.7 + \frac{F}{H_o'}\right)^2}$$

$$= 0.1 \text{ for } \frac{F}{H_o'} > 2.05 \tag{3}$$

where F is the breakwater freeboard defined as $(h - d_s)$. The maximum ponding level occurs at $F/H_o' = 0.7$ because this is the point just before the seaward flow over the top of the breakwater occurs. Note that there is scatter in the data used to develop equation (3) with approximately 90 percent of all data points falling within 20 percent of the equation. A sensitivity analysis shows that this scatter is not important for this report, because flow rates are weakly influenced by the value of P.

Note that the laboratory tests used to develop equation (2) show some ponding for high breakwaters not overtopped and submerged breakwaters. This ponding occurs because the breakwater reduces the wave height landward of the structure and the change in wave height causes wave setup (Longuet-Higgins, 1967).

Overtopping tests by Diskin, Vajda, and Amir (1970) show that the net overtopping rate, q_n, for breakwaters may be estimated from

$$q_n = q_o\left(1 - \frac{h_b}{P}\right) \tag{4}$$

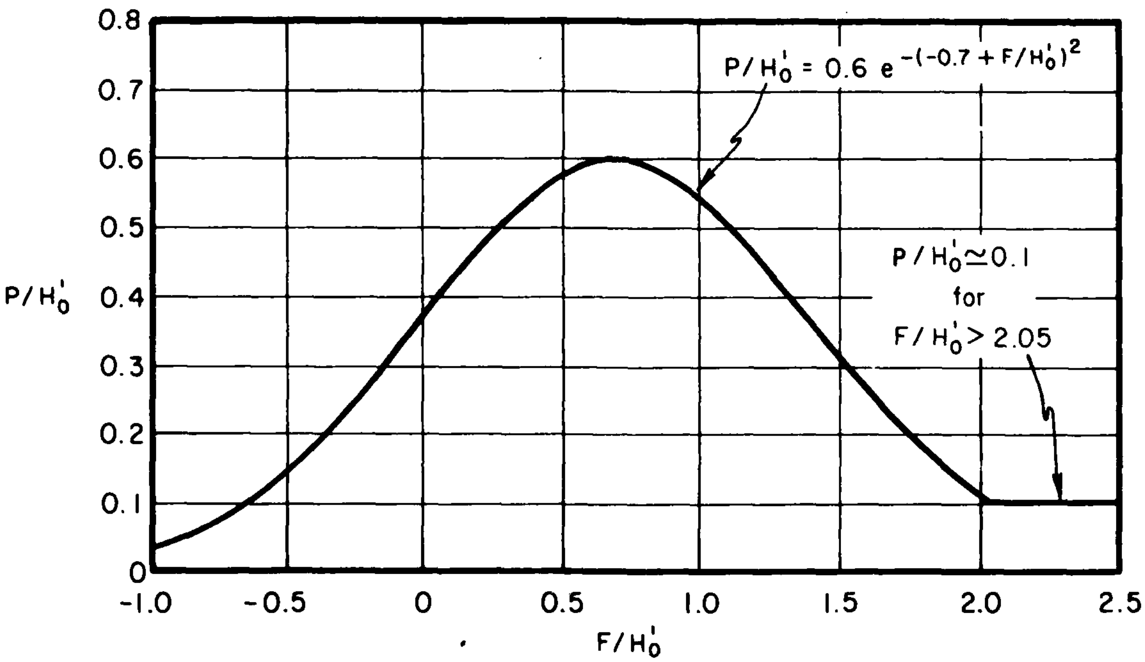

Figure 3. Ponding levels for porous multilayered breakwaters (after Diskin, Vajda, and Amir, 1970).

2. Offshore Breakwaters with Gaps.

Overtopping of breakwaters causes a buildup of water in the zone landward of the structure. If there are gaps between the breakwaters and the breakwaters are not connected to shore, the buildup of water landward of the breakwaters causes flow through the openings (Fig. 4). One method of estimating the exit flow through breakwater gaps or inlets is to use a combined continuity-energy equation for discharge.

$$\overline{Q} = \overline{V}A_c = C_d \sqrt{2gh_b}\, A_c \tag{5}$$

where C_d is a discharge coefficient, A_c is cross-sectional flow area at the water level of interest, and $\overline{V}$ is the mean velocity of water flowing through the gaps. Many factors may influence the magnitude of C_d but, as a first estimate, $C_d = 0.8$ is recommended for gaps. The discharge coefficient for spaces between breakwaters and the shoreline, C_{de}, has a recommended value of $C_{de} = 1.0$.

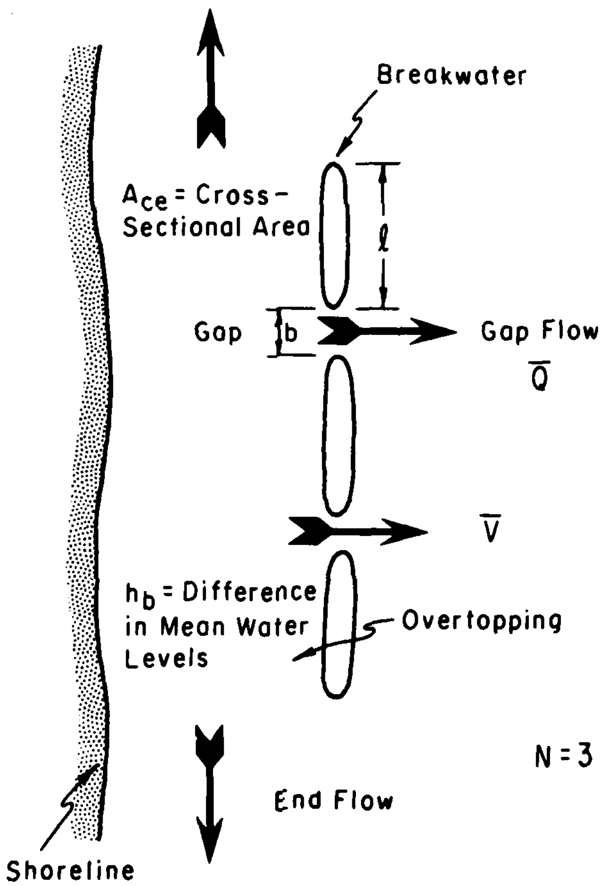

Figure 4. An offshore breakwater system.

Note that in this first approximation of breakwater gap flow that the waves are assumed to approach approximately normal to the breakwaters and shoreline, so the longshore current can be neglected. Other effects such as diffraction, refraction, reflection, and wave-current interactions have not been considered.

If incident wave conditions do not vary rapidly with time, a condition will be reached where water flowing into the zone protected by the breakwaters will equal the exit flow through breakwater gaps or inlets. The equation describing this condition is

$$q_o\left(1 - \frac{h_b}{P}\right) N\ell = \sqrt{2gh_b}\ \left(C_d B d_s (N - 1) + 2C_{de}A_{ce}\right) \tag{6}$$

where N is the number of breakwaters, A_{ce} is the cross-sectional flow area between the breakwaters and shoreline at the end of the system, and B is the gap width between breakwaters (Fig. 4). Solving equation (6) and putting into dimensionless form, the dimensionless velocity,

$$v = \frac{\overline{V}}{C_d\sqrt{2g\ P}}$$

becomes a function of a single coefficient, K, where

$$K = \frac{\sqrt{2g\ P}\ \left[C_d B d_s (N - 1) + 2C_{dc}A_{ce}\right]}{q_o \ell N} \tag{7}$$

Figure 5, which gives the relation between dimensionless velocity and K, shows that any combination of factors causing K to increase will produce a smaller dimensionless velocity. For example, keeping all other factors constant, if the gap spacing B is increased, K will increase and $\overline{V}$ will be reduced.

K and the resulting velocity may be easily solved using equation (7) and Figure 5. The computer program BWFLOW2 can also be used to solve the velocity and flow through breakwater gaps due to overtopping. This program is recommended if a large number of calculations are needed. The program is also suggested any time irregular wave conditions are assumed, because irregular wave overtopping rates are a complex function of the overtopping rate given by equation (1). The cost of running BWFLOW2 is a few cents per condition of interest.

It is recommended that $\overline{V}$ be kept below 0.5 foot (0.15 meter) per second for extreme design conditions. Velocities much higher than this value could transport significant amounts of sediment out of the breakwater system and may cause scour around the breakwaters. Recall that $\overline{V}$ is an average velocity through the gap and that local velocities in breakwater vicinity may be considerably higher.

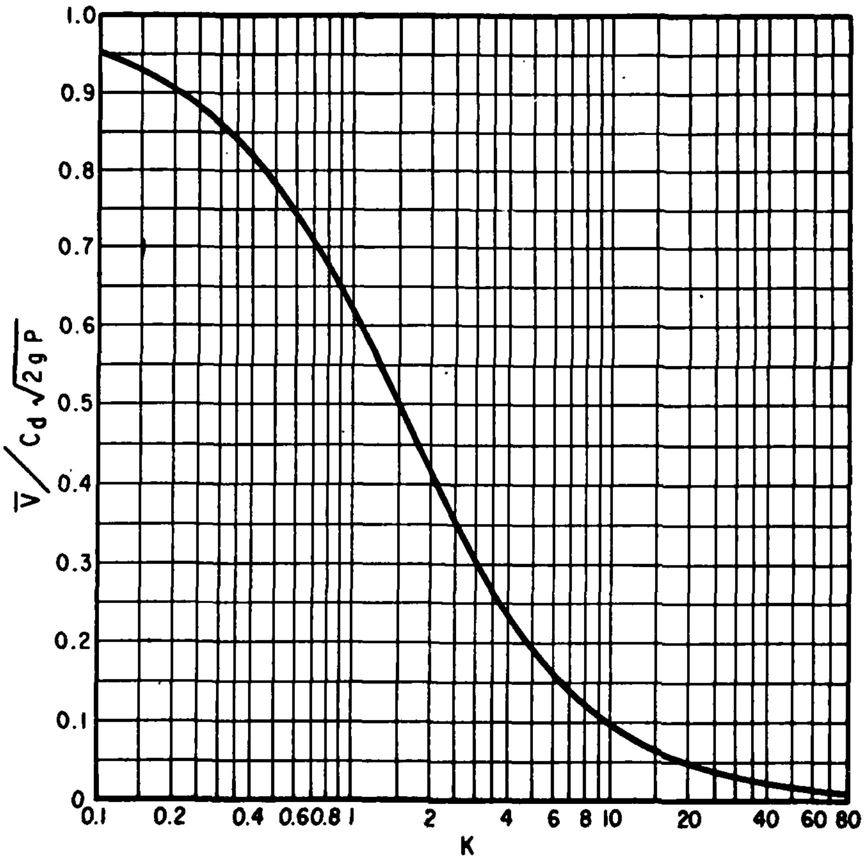

Figure 5. Dimensionless velocity as a function of K.

III. EXAMPLE PROBLEMS

Example problems are presented to illustrate the steps required for manual or computer computation. The examples indicate the relative importance of the breakwater design variables on the magnitude of $\overline{V}$.

* * * * * * * * * * * * * * * EXAMPLE PROBLEM 1 * * * * * * * * * * * * * * *

GIVEN: Four rubble-mound offshore breakwaters have the design conditions illustrated in Figure 6.

FIND: $\overline{V}$, assuming a monochromatic wave height of 8.0 feet (2.44 meters) at the structure.

SOLUTION: Manual computation is illustrated in this example.

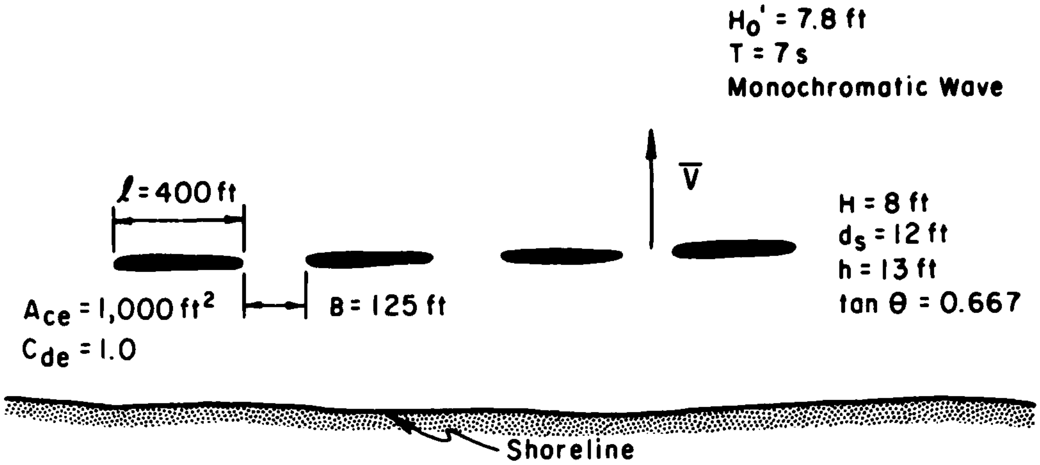

Figure 6. Design conditions for example problem 1.

The first step in computations is to determine values for the dimensionless parameters:

$$\frac{H_o'}{gT^2} = \frac{7.8}{32.2(7)^2} = 0.0049$$

and

$$\frac{d_s}{H_o'} = \frac{12}{7.8} = 1.53$$

From Figure 2, α and Q_o^* are estimated as $\alpha = 0.053$ and $Q_o^* = 0.019$. The surf parameter and resulting runup are determined using equation (2):

$$\xi = \frac{0.667}{\sqrt{\dfrac{8}{5.12(7^2)}}} = 3.74$$

and

$$R = \frac{0.692(8)(3.74)}{(1 + 0.504[3.74])} = 7.17 \text{ feet}$$

The breakwater freeboard is $F = h - d_s = 13 - 12 = 1.0$ foot.

The overtopping rate, q_o, given by equation (1) is

$$q_o = \sqrt{32.2(0.019)(7.8)^3}\left(\frac{7.17 - 1.}{7.17 + 1.}\right)^{\frac{0.1085}{0.053}}$$

= 9.53 cubic feet per second per foot of breakwater crest.

From equation (3) the ponding level is

$$P = 7.8(0.6)e^{-(-0.7 + 1.0/7.8)^2} = 3.36 \text{ feet}$$

From equation (7)

$$K = \frac{\sqrt{64.4\ 3.36}\ [0.8(125)\ 12(4 - 1) + 2(1.0)\ 1{,}000]}{9.53(400)\ 4}$$

or

$$K = 5.4$$

The corresponding dimensionless velocity is

$$\frac{\bar{V}}{C_d\sqrt{2g\ P}} = 0.18 \text{ for } K = 5.4 \text{ from Figure 5}$$

and

$$\bar{V} = 0.18(0.8)\sqrt{64.6\ 3.36} = 2.11 \text{ feet per second.}$$

* * * * * * * * * * * * * * * * EXAMPLE PROBLEM 2 * * * * * * * * * * * * * * * *

GIVEN: The same breakwater system as in example 1.

FIND: $\bar{V}$ for irregular wave conditions with a significant wave height, H_s = 8.0 feet (2.44 meters).

SOLUTION: The computer solution is illustrated in this example with the input shown in Table 1. Resulting computer output is given in Table 2. The predicted velocity is $\bar{V}$ = 1.33 feet (0.14 meter) per second. This velocity is lower than the $\bar{V}$ obtained for monochromatic waves in example 1 (2.11 feet per second), because irregular waves of a given significant wave height have less overtopping than monochromatic waves.

Table 1. Computer program input for example problem 2.

1	4	400.	125.	7.77	8.	7.	12.	1[illegible].
.667		.019	.053	.8	-1.0	1000.		

Table 2. Computer program output for example problem 2.

**** IRREGULAR WAVES ****

N	L(FT)	B(FT)	HO(FT)	H(FT)	T(SEC)	DS(FT)	HS(FT)	TANT	Q*	ALPHA
8	400.00	125.00	7.8	8.0	7.0	12.0	15.0	.667	.0190	.0530

CD	CDE	ACE(FT2)	RUNUP(FT)	QO(CFS)	P(FT)	K	V(FPS)
.8	1.0	1000.00	7.17	5.91	2.288	7.12	1.33

* * * * * * * * * * * * * * * EXAMPLE PROBLEM 3 * * * * * * * * * * * * * * *

GIVEN: Three rubble-mound offshore breakwaters are located with $d_s = 12$ feet (3.7 meters), $\ell = 250$ feet (76.2 meters), $\tan\theta = 0.667$, and $A_{ce} = 1{,}440$ square feet (134 square meters).

FIND: The influence of breakwater freeboard, incident wave height, wave period, gap spacing, and shore attachment on $\bar{V}$.

SOLUTION: The computer program was used to make these calculations and results are given in Figures 7 to 10. Figure 7 shows that an increase in breakwater freeboard or gap to length ratio causes $\bar{V}$ to decrease. An increase in incident wave height and in wave period produces an increase in $\bar{V}$ as expected (Figs. 8 and 9). Shore attachment with impermeable walls forces more flow through breakwater gaps than for a detached system (Fig. 10). The most dramatic effect of shore attachment occurs for relatively small breakwater gaps.

* *

IV. SUMMARY AND CONCLUSIONS

A method is presented for estimating the first approximation of the water velocity and flow rate through breakwater gaps caused by wave overtopping. Calculations can be performed either by hand, using a dimensionless curve, or by a computer program, BWFLOW2, available in the Corps of Engineers Computer Library. Examples of both calculation methods are given to illustrate the relative influence of various design parameters on the magnitude of the gap velocity, $\bar{V}$. It is suggested that $\bar{V}$ not exceed 0.5 foot per second. High values of $\bar{V}$ may produce scour around structures and transport sediment out of the zone protected by the breakwaters.

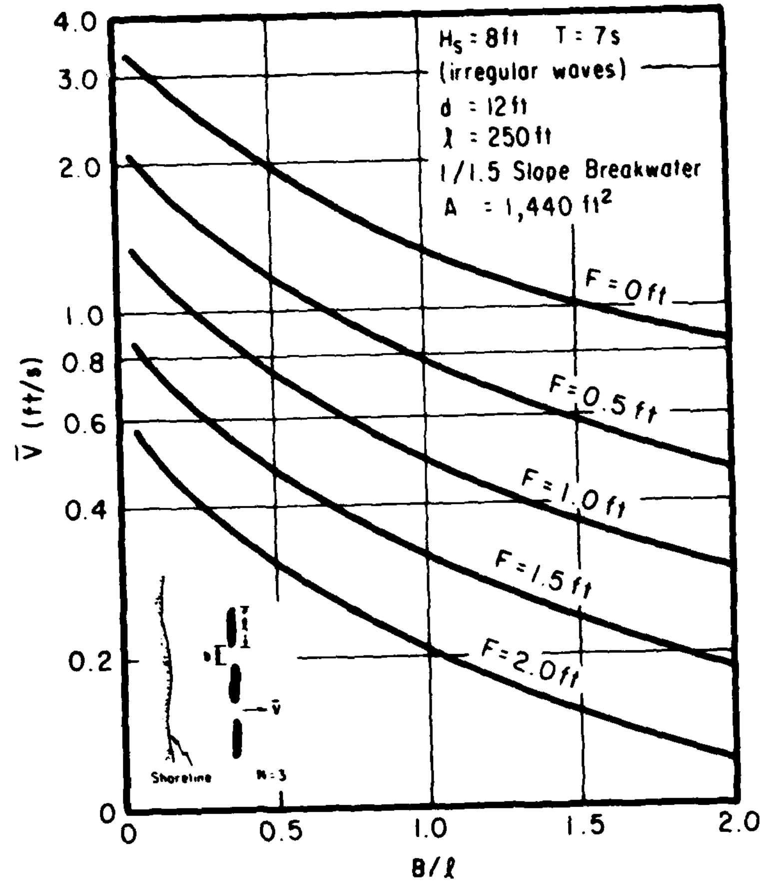

Figure 7. Effect of breakwater freeboard and gap spacing on $\overline{V}$.

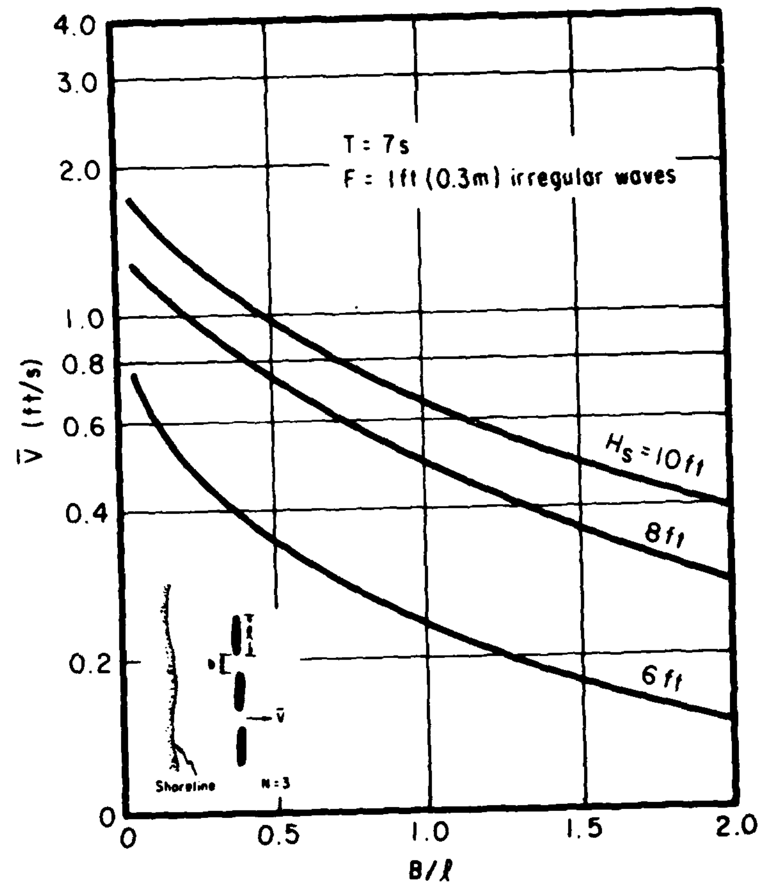

Figure 8. Effect of incident wave height and gap spacing on $\overline{V}$.

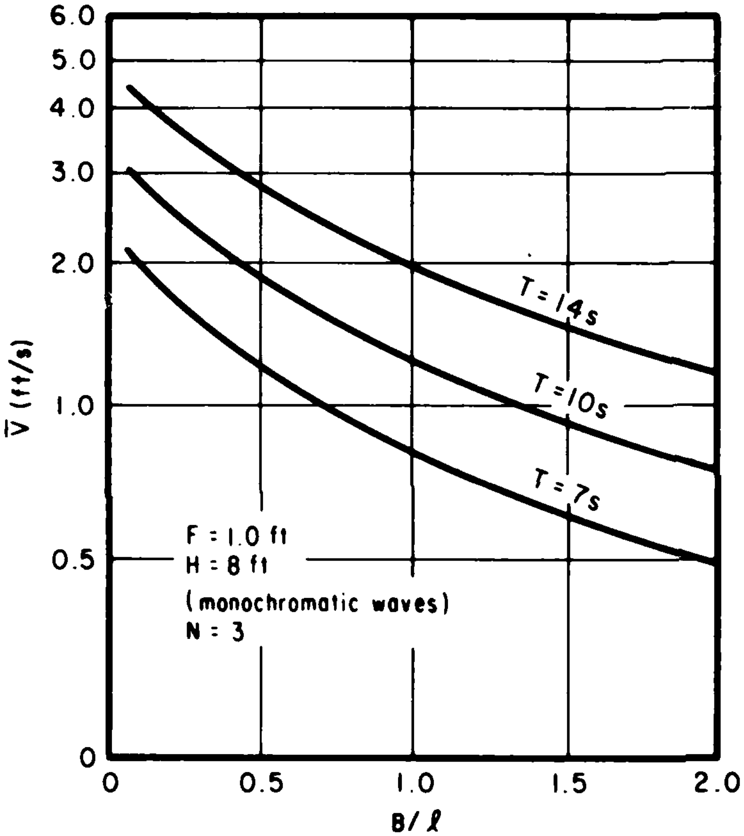

Figure 9. Effect of wave period and gap spacing on $\bar{V}$.

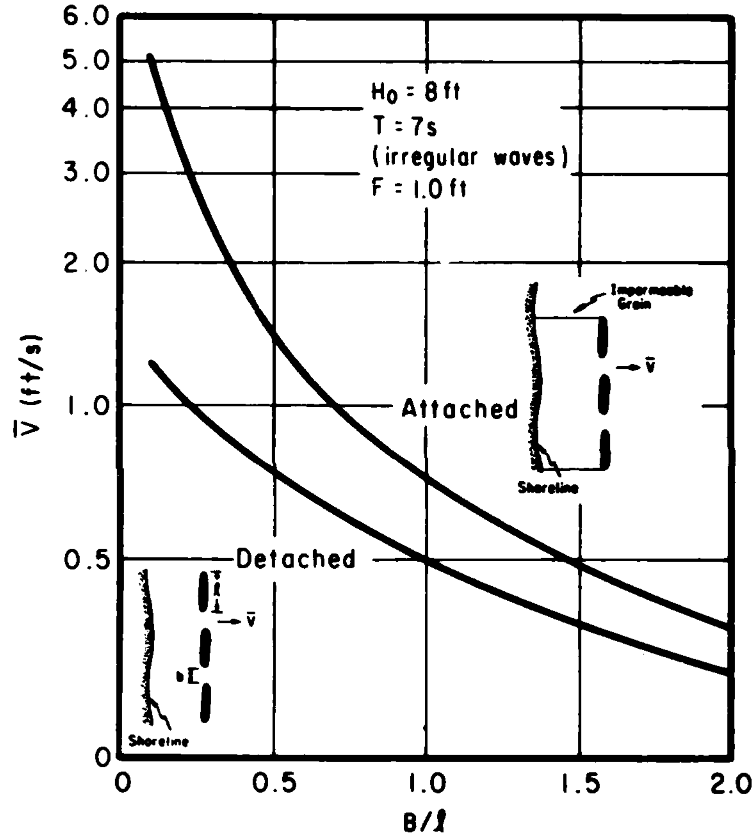

Figure 10. Effect of shore attachment and gap spacing on $\bar{V}$.

LITERATURE CITED

AHRENS, J.P., "Prediction of Irregular Wave Overtopping," CETA 77-7, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., Dec. 1977.

AHRENS, J.P., and McCARTNEY, B.L., "Wave Period Effect on the Stability of Riprap," *Proceedings of Civil Engineering in the Oceans/III*, American Society of Civil Engineers, 1975, pp. 1019-1034 (also Reprint 76-2, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., NTIS A029 726).

DISKIN, M., VAJDA, M., and AMIR, I., "Piling-Up Behind Low and Submerged Permeable Breakwaters," *Journal of Waterways and Harbors Division*, No. WW 2, May 1970, pp. 359-372.

LONGUET-HIGGINS, M.S., "On the Wave-Induced Difference in Mean Sea Level Between the Two Sides of a Submerged Breakwater," *Journal of Marine Research*, Vol. 25, No. 2, 1967, pp. 148-153.

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vols. I, II, and III, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977, 1,262 pp.

WEGGEL, J.R., "Wave Overtopping Equation," *Proceedings of the 15th Coastal Engineering Conference*, American Society of Civil Engineers, 1976, pp. 2737-2755 (also Reprint 77-7, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., NTIS A042 678).

Seelig, William N.

Estimation of flow through offshore breakwater gaps generated by wave overtopping / by William N. Seelig and Todd L. Walton, Jr. -- Fort Belvoir, Va. : U.S. Coastal Engineering Research Center ; Springfield, Va. : available from National Technical Information Service, 1980.

[21] p. : ill. : 27 cm. -- (Technical aid -- U.S. Coastal Engineering Research Center ; no. 80-8)

Includes bibliographical references.

This report presents a method for estimating the net flow through the gaps of offshore segmented breakwaters caused by wave overtopping of the breakwaters. The method was developed so that either monochromatic or irregular waves can be specified.

1. Breakwaters. 2. Wave height. 3. Wave overtopping. 4. Wave period. 5. Waves. I. Title. II. Walton, Todd L. III. Series: U.S. Coastal Engineering Research Center. Technical aid no. 80-8.

TC203 .U581ta no. 80-8 627

Seelig, William N.

Estimation of flow through offshore breakwater gaps generated by wave overtopping / by William N. Seelig and Todd L. Walton, Jr. -- Fort Belvoir, Va. : U.S. Coastal Engineering Research Center ; Springfield, Va. : available from National Technical Information Service, 1980.

[21] p. : ill. : 27 cm. -- (Technical aid -- U.S. Coastal Engineering Research Center ; no. 80-8)

Includes bibliographical references.

This report presents a method for estimating the net flow through the gaps of offshore segmented breakwaters caused by wave overtopping of the breakwaters. The method was developed so that either monochromatic or irregular waves can be specified.

1. Breakwaters. 2. Wave height. 3. Wave overtopping. 4. Wave period. 5. Waves. I. Title. II. Walton, Todd L. III. Series: U.S. Coastal Engineering Research Center. Technical aid no. 80-8.

TC203 .U581ta no. 80-8 627

Seelig, William N.

Estimation of flow through offshore breakwater gaps generated by wave overtopping / by William N. Seelig and Todd L. Walton, Jr. -- Fort Belvoir, Va. : U.S. Coastal Engineering Research Center ; Springfield, Va. : available from National Technical Information Service, 1980.

[21] p. : ill. : 27 cm. -- (Technical aid -- U.S. Coastal Engineering Research Center ; no. 80-8)

Includes bibliographical references.

This report presents a method for estimating the net flow through the gaps of offshore segmented breakwaters caused by wave overtopping of the breakwaters. The method was developed so that either monochromatic or irregular waves can be specified.

1. Breakwaters. 2. Wave height. 3. Wave overtopping. 4. Wave period. 5. Waves. I. Title. II. Walton, Todd L. III. Series: U.S. Coastal Engineering Research Center. Technical aid no. 80-8.

TC203 .U581ta no. 80-8 627

Seelig, William N.

Estimation of flow through offshore breakwater gaps generated by wave overtopping / by William N. Seelig and Todd L. Walton, Jr. -- Fort Belvoir, Va. : U.S. Coastal Engineering Research Center ; Springfield, Va. : available from National Technical Information Service, 1980.

[21] p. : ill. : 27 cm. -- (Technical aid -- U.S. Coastal Engineering Research Center ; no. 80-8)

Includes bibliographical references.

This report presents a method for estimating the net flow through the gaps of offshore segmented breakwaters caused by wave overtopping of the breakwaters. The method was developed so that either monochromatic or irregular waves can be specified.

1. Breakwaters. 2. Wave height. 3. Wave overtopping. 4. Wave period. 5. Waves. I. Title. II. Walton, Todd L. III. Series: U.S. Coastal Engineering Research Center. Technical aid no. 80-8.

TC203 .U581ta no. 80-8 627